Salmonella spp. Risk Assessment for Production and Cooking of Blade Tenderized Prime Rib

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INTRODUCTION

The meat industry must provide consistent quality and uniformity in its products to remain competitive. The quality characteristic that has received primary focus is tenderness. The primary technologies used to ensure tenderness and retail cut uniformity are blade tenderization and restructuring; technologies very effective and critical to the economic well being of the meat industry.

Blade tenderization is one of the most effective methods of meat tenderization, particularly for cuts higher in connective tissue. It also can significantly reduce the variability in tenderness regardless of the muscle. Even though the generic microbiological quality of blade tenderized muscle has been shown to be equivalent to non-tenderized controls on a per gram basis (Boyd et al., 1978), bacteria may be translocated into the muscle. Therefore, research was done to define effective cooking schedules for resultant products.

In November 1997, the National Advisory Committee on Microbiological Criteria for Foods (NACMCF), Meat and Poultry Subcommittee stated that A*Due to the low probability of pathogenic organisms being present in or migrating from the external surface to the interior of beef muscle, cuts of intact muscle (steaks) should be safe if the external surfaces are exposed to temperatures sufficient to effect a cooked color change.*@ However, if the surface of an intact muscle or muscle system is violated by mechanical tenderization (blade tenderization), contamination may be carried from the surface to the interior of the cut. The NACMCF Meat and Poultry Subcommittee also stated in 1997 that there is a lack of scientific data to address the hazards associated with those processes that may cause translocation of pathogens to the interior of meat cuts. Because of the widespread use of mechanical tenderization, and the potential food safety risks it may pose, the Beef Industry Food Safety Council (BIFSCO) identified this research as a priority for the beef industry.

Kansas State University has successfully performed a similar project "*Escherichia coli* O157:H7 Risk Assessment for Production and Cooking of Blade Tenderized and Fibrinogen Process Beef Steaks" and presented results to USDA-FSIS during the public meeting held in Washington, D.C. on March 8, 1999. Results indicate that the blade tenderization process transfers 3-4% of surface contamination to the interior of the muscle. Cooking studies indicated that a target internal temperature of 120°F produced greater ($p \leq 0.05$) log reductions (CFU/g) in non-tenderized (NT) vs. tenderized (T) steaks (5.2 log reduction vs. 3.2 log reduction), showing that blade tenderized steaks presented an increased risk. However, at endpoint temperatures of 140°, 150°, 160° and 170°F, log reductions were greater than 6 logs in both T and NT steaks, which represented virtually complete destruction. At cooking temperatures ranging from rare (130°F) to well done (170°F), there were no differences in *E. coli* O157:H7 between intact and non-intact steaks using the oven broiling method. Both intact and non-intact steaks are safe for consumers when cooked to the endpoint temperatures evaluated in the study by the oven broiling method. Although this study evaluated the risk of *E. coli* O157:H7, other foodborne pathogens such as *Salmonella* and *Listeria monocytogenes* have not been considered. It is possible that the translocation of these pathogens could be different compared to *E. coli* O157:H7 and further, the cooking protocols required for inactivation of *Salmonella* and *Listeria monocytogenes* could be different.

Traditional Prime Rib processing requires cooking of the rib to a desired degree of doneness and holding at a temperature for long periods of time. The product is normally served over the whole day or chilled at the end of the day's operation and re-heated the following day in restaurant

operations. Blade tenderization is normally used when a lower grade muscle is used or when a consistent tenderness is desired. There were two outbreaks reported to Centers for Disease Control and Prevention in 1971 and 1986 where Prime Rib has been implicated as a possible source of contamination and *Clostridium perfringens* has been identified as the etiologic agent. The cooking temperatures vary from 110 °F to 145 °F and holding for over 10 to 12 hours at approximately 120 °F. The low cooking temperature in addition to long holding times presents unique opportunity for the pathogens to survive and cause foodborne outbreaks. Presently, regulations are not in place regarding the cooking and safe heating parameters have not been identified.

Therefore, research was performed to determine the process and preparation protocols to ensure the safety of this product. By validating these processes and cooking protocols against *Salmonella* spp., suppliers and food service industries will be able to effectively establish standard cooking recommendations for food service HACCP programs for preparation of this product.

The objective of this research was to determine the effectiveness of rare to well done cooking temperatures on reducing *Salmonella* spp. populations contaminating the interior of prime rib as a result of blade tenderization of artificially contaminated beef sub-primal surfaces.

MATERIALS AND METHODS

***Preparation and Cooking of Blade Tenderized Prime Rib*:** Boneless beef ribs, roast ready (NAMP 109D) were obtained from a wholesale vendor. The product was surface inoculated (non-fat side) to target contamination level of 10^7 *Salmonella* spp./cm^2. After an attachment period of 2 hrs, one set of prime rib was blade tenderized (fat side down) using one pass through a Ross tenderizer with the unit-s conveyor moving 1.25 inches (31.75 mm) forward and 0.5 inches (12.7 mm) laterally between each blade cycle. The 448 blades of the tenderizer produce 32 incisions per square inch. The unit was thoroughly sanitized and disinfected between each subprimal processed. Tenderized prime ribs were fabricated using North American Meat Processors guidelines.

Product was held at 4 °C until cooking (ca. 1 hr). A Type T thermocouple was inserted into the geometric center of each product through the side. Products were cooked in a conventional kitchen oven at 375 °F to a specific end-point temperature (uncooked, 110 and120 °F) with the individual cooking curves for each product being monitored and recorded. At this end-point, the product was removed from the oven and tempered at room temperature for 1 hour. The product was then be placed in a holding oven set at 120 °F for a further 2 h.

Microbiological samples were obtained after blade tenderization, after reaching target temperature, after 1 h of tempering, after 30, 60, 120 and 180 min of holding at 120 °F. A center core of each product then was diluted in chilled peptone water buffer to bring the meat temperature down quickly. This sample was microbiologically analyzed for *Salmonella* spp.

Salmonella spp. Cultures: A five strain cocktail of *Salmonella* spp. was used in all investigations. Cultures were grown in tryptic soy broth at 35 °C for 18 h to stationary phase, centrifuged and cell pellets from all five strains resuspended in 0.1% peptone water to establish a cocktail inoculum. The suspension and inoculation volumes for this inoculum preparation protocol are well established in our laboratory to provide accurate target inoculation rates on meat products by applying a light mist of the inoculum onto the exterior meat surfaces.

Enumeration of Salmonella spp.: Surviving *Salmonella* spp. populations were enumerated by direct plating on Xylose Lysine De-oxycholate Agar (XLD) and modified Xylose Lysine De-oxycholate Agar (mXLD) for *Salmonella* spp. Although XLD is selective for *Salmonella* spp., we have found that recovery of injured cells is fairly inefficient on XLD which can provide an erroneous indication of process lethality. By duplicate plating on mXLD, a much less selective agar, a more accurate estimate of process lethality can be obtained.

Bacterial population reductions due to cooking schedule were determined based on a comparison to inoculated but uncooked control steaks receiving the same processing treatment. The remainder of each product was held at 4°C. If a specific cooking time/temperature reduces the inoculated *E. coli* O157:H7 and *Salmonella* spp. population to below the detection level of direct plating, these stored samples were enriched according to modified USDA protocols. Four replications of the experiment were performed with duplicate product being cooked and analyzed for each cooking treatment within replications.

RESULTS AND DISCUSSION

Cooking of prime ribs to internal temperatures of 110 and 120 °F and subsequent holding at 120 °F for 1 h resulted in reductions of 4.54 and 4.80 log CFU/g of *Salmonella* spp. from initial levels of 5.76 log CFU/g in prime rib, respectively. Although the internal temperatures reached during the cooking process are minimal, and are not expected to result in destruction of *Salmonella* spp., the microbial cells on the surface of the prime rib would be exposed to higher, lethal temperatures. The heat transfer from the oven, to the internal sections of the prime rib would result in a gradient, with higher temperatures near the meat surface, with decreasing temperatures near the center, with the center being the coldest spot.

Our initial studies with blade tenderized beef subprimals (inside rounds) revealed translocation of *E. coli* O157:H7 present on the surface throughout the interior of the muscle. The high level inoculum was applied at a level of 6 log CFU/g over the top 1 cm strip, and although a dilution effect was seen throughout the core, approximately 3 logs of *E. coli* O157:H7 were recovered at a depth of 6 cm. The geometric center of the core, which in regard to steak cooking, is the slowest to reach a target temperature, harbored 4 logs of *E. coli* O157:H7. The low inoculum (3.2 log CFU/g on surface) produced a similar trend, showing the relocation of approximately 1.8 logs to the geometric center of the steaks. Overall, the process was found to carry 3-4% of the surface organisms to the center of the core, regardless of surface inoculation level.

Although cooking of tenderized steaks to a target end point temperature of 120 °F showed 3.2 log reduction, greater reductions observed in prime rib were probably due to the larger size, resulting in longer cook times (Phebus et al., 1999). Johnston et al. (1978) reported that salmonellae survived on both the surface and in the core of mechanically tenderized roasts oven cooked to an internal temperature of 130°F. The authors hypothesized that the presence of viable salmonellae on surface could be either due to purging of the cells from the center or survival on the surface. However, the authors used convection cooking, where the temperature rise would be faster compared to the conventional kitchen oven used in the present study. Further, cooking of prime ribs involves a "tempering" process, where the prime ribs are kept at room temperature for varying times and then placed in a holding oven, at approximately 120 °F. The "tempering" process, along with holding results in greater temperature increases at the center of the prime rib, compared to when the product

is placed in a refrigerator as followed by Johnston et al. (1978). This could have resulted in greater *Salmonella* spp. reductions observed in the present study.

SUMMARY AND CONCLUSIONS

Results of the present study indicate that although translocation of the surface contamination does occur, cooking to internal temperatures ≥ 110 °F would result in significant reduction in potential public health risk when accompanied by a 1 h minimum tempering step. Even though the prime rib preparation process utilizes very low cooking temperatures, the long cooking time and tempering period (accompanied by a significant post-cook temperature rise) results in substantial process lethality and a safe final product.

In this study, we intentionally inoculated prime rib with high levels of *Salmonella* spp. in order to quantify the effect of mechanical tenderization on the translocation of bacteria from the surface of the beef cuts into interior of the muscle. The levels of contamination used do not reflect levels that are likely to be present. In actual practice, the source point of contamination for *Salmonella* spp. is at the carcass level and contamination is prevented or reduced through application of numerous processing steps, including validated anti-microbial technologies and enforcement of USDA-FSIS's zero tolerance policy for physical defects. The potential of contamination is further reduced by the removal of the carcass surface by trimming before mechanical tenderization.

This study only lends insight into control of risks in blade tenderized prime rib using oven broiling. This method of cooking applies a uniform temperature to the prime rib and also results in a longer cooking process compared to convection ovens used in some restaurants. More intensive evaluations of these cooking methods for adequate risk control are warranted.

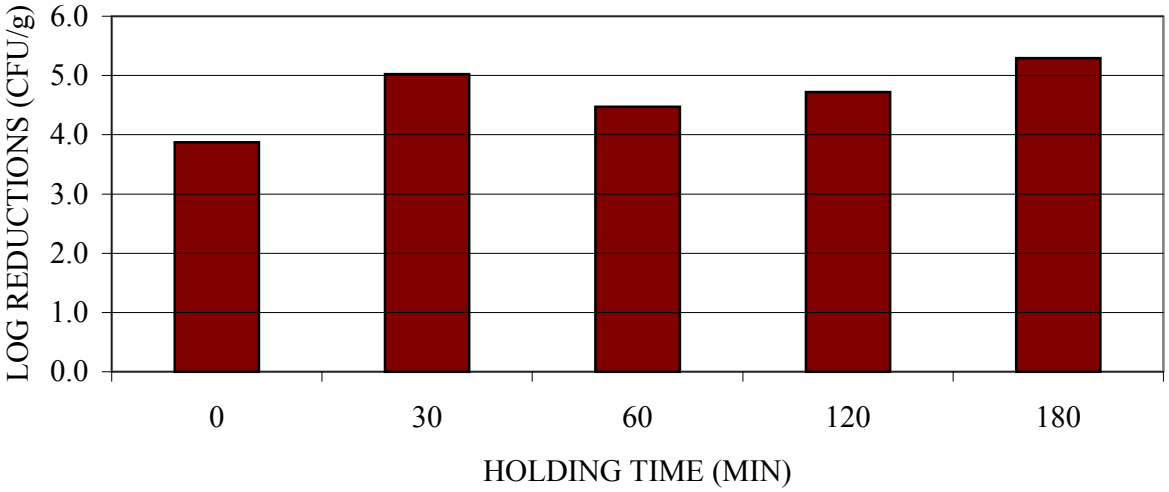

Fig. 1. *Salmonella* spp. reductions attained by cooking prime rib to internal temperatures of 110 or 120 °F (pooled data) and holding for various periods at 120 °F.